United States Government Accountability Office

GAO

Report to Congressional Requesters

May 2009

DEFENSE ACQUISITIONS

Assessments Needed to Address V-22 Aircraft Operational and Cost Concerns to Define Future Investments

GAO-09-482

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Highlights

Highlights of GAO-09-482, a report to congressional requesters

Why GAO Did This Study

Since the 1980s, the V-22, developed to transport combat troops, supplies, and equipment for the U.S. Marine Corps and to support other services' operations, has experienced several fatal crashes, demonstrated various deficiencies, and faced virtual cancellation—much of which it has overcome. Although until recently deployed in Iraq and regarded favorably, it has not performed the full range of missions anticipated, and how well it can do so is in question. In view of concerns about the V-22 program, you asked us to determine if the V-22 will perform as promised, and if it will, at what cost. GAO reviewed (1) current MV-22 operations in Iraq; (2) strengths and deficiencies in terms of the capabilities expected of the V-22; and (3) past, current, and future costs. GAO reviewed a range of program documents and data, interviewed program officials, operators and others; and observed MV-22 operations in Iraq and shipboard.

What GAO Recommends

The Secretary of Defense should require a new alternatives analysis of the V-22 and determine how cost effective it is in meeting the Marine Corps medium lift needs, and possibly other services' uses. DOD should also require that the Marine Corps develop a prioritized strategy to improve system suitability, reduce operational costs, and align future budget requests accordingly. DOD concurred with the second recommendation, but not the first. GAO believes both recommendations remain valid.

View GAO-09-482 or key components.
For more information, contact Michael J. Sullivan at 202-512-4841 or sullivanm@gao.gov.

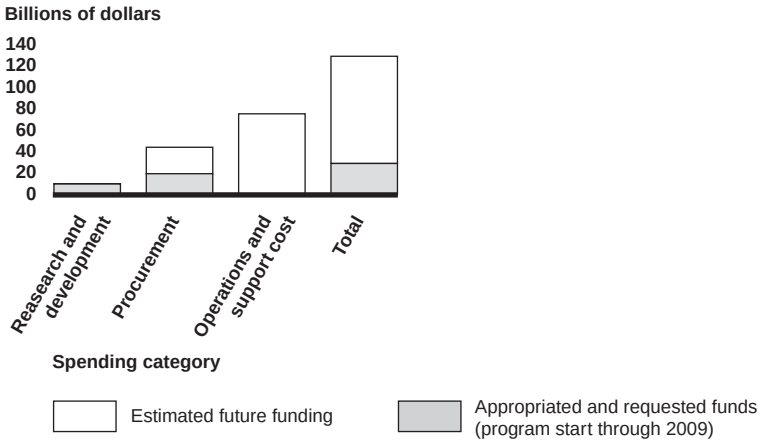
What GAO Found

As of January 2009, the 12 MV-22s (Marine Corps variant of the V-22) in Iraq successfully completed all missions assigned in a low threat theater of operations—using their enhanced speed and range to engage in general support missions and deliver personnel and internal cargo faster and farther than the legacy helicopters being replaced. Noted challenges to operational effectiveness raise questions about whether the MV-22 is best suited to accomplish the full repertoire of missions of the helicopters it is intended to replace. Additionally, suitability challenges, such as unreliable component parts and supply chain weaknesses, led to low aircraft availability rates.

MV-22 operational tests and training exercises identified challenges with the system's ability to operate in other environments. Maneuvering limits and challenges in detecting threats may affect air crew ability to execute correct evasive actions. The aircraft's large size and inventory of repair parts created obstacles to shipboard operations. Identified challenges could limit the ability to conduct worldwide operations in some environments and at high altitudes similar to what might be expected in Afghanistan. Efforts are underway to address these deficiencies, but some are inherent in the V-22's design.

V-22 costs have risen sharply above initial projections—1986 estimates (stated in fiscal year 2009 dollars) that the program would build nearly 1000 aircraft in 10 years at $37.7 million each have shifted to fewer than 500 aircraft at $93.4 million each—a procurement unit cost increase of 148 percent. Research, development, testing, and evaluation costs increased over 200 percent. To complete the procurement, the program plans to request approximately $25 billion (in then-year dollars) for aircraft procurement. As for operations and support costs (O&S), the Marine Corps' V-22's cost per flight hour today is over $11,000—more than double the targeted estimate.

V-22 Funding Profile (Then-Year Dollars)[a]



Source: *V-22 December 2007 Selected Acquisition Report.*

[a]O&S expenditures to date are not reported in the SAR, O&S funding includes past and future needs

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Abbreviations

COEA	Cost and Operational Effectiveness Analysis
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
FMC	Full Mission Capability
KPP	Key Performance Parameter
KTAS	Knots True Airspeed
MC	Mission Capability
mm	Millimeter
NM	Nautical Miles
O&S	Operations and Support

GAO
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United States Government Accountability Office
Washington, DC 20548

May 11, 2009

The Honorable Henry A. Waxman
Chairman
The Honorable John D. Dingell
Chairman Emeritus
Committee on Energy and Commerce
House of Representatives

The Honorable Edolphus Towns
Chairman
Committee on Oversight and Government Reform
House of Representatives

The Honorable Bart Stupak
Chairman
Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

Since the V-22 Osprey began development in the mid-1980s, it has experienced several fatal crashes, demonstrated a variety of deficiencies, and faced the virtual cancellation of the program—much of which it has been able to overcome. There are two variants of the V-22 tilt-rotor aircraft currently being used: the MV-22 variant for the Marine Corps will replace the CH-46E helicopter as the Marine Corps' medium-lift aircraft—to be used along with the heavy-lift CH-53[1]—to fulfill operational requirements such as transporting combat troops, supplies, and equipment. The Air Force's CV-22 variant will augment existing U.S. Special Operations Command (USSOCOM) aircraft and the MV-22. Until recently, the MV-22 was deployed in Iraq and, while it accomplished assigned missions there, its usage did not encompass the full range of tasks anticipated for the aircraft, and identified operational challenges raise questions concerning how effectively it can perform the full range of anticipated missions.

In view of our past work and others' highlighting concerns about the V-22 program, you asked us to determine whether the V-22 will perform as

[1]CH-53 helicopters are also being used, in part, to conduct medium-lift operations for the Marine Corps.

promised, and if it will, at what cost. To do this, we reviewed the V-22 aircraft from a variety of perspectives: (1) its current operations in Iraq; (2) its strengths and deficiencies in terms of the capabilities expected of it; and (3) its past, current, and future costs.

In the process of conducting our review, we examined how well the aircraft has performed in theater since October 2007; key testing, safety, and production quality issues that might affect its ability to perform planned missions; its costs, schedule, and quantities since 1986; and changes in key performance parameters (KPP) and other requirements.[2] Throughout our report, "requirements" refers to MV-22 capabilities stated in the Cost and Operational Effectiveness Analysis (COEA), Joint Operational Requirement Documents (JORD), and Capabilities Production Documents (CPD) and Capabilities Development Documents (CDD).[3] We reviewed a wide range of documents containing MV-22 program data related to cost and other factors dating from program start in 1986 to the present; past and current KPPs and other critical requirements; test assessments, development and operational tests, and internal program documents; and briefs and reports. We interviewed a wide range of Department of Defense (DOD), Marine Corps, V-22 program, and contractor officials; MV-22 operators, maintainers, logisticians, combat troops and their commanders; and others both in the United States and in Iraq. We also observed MV-22 shipboard operations during training off the coast of North Carolina and operation of the 12 MV-22s deployed in Iraq. Our assessment focuses on the MV-22 but in most instances applies to the CV-22, as the two variants have a common airframe and engine, but avionics do vary.

We conducted this performance audit from June 2008 to May 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions

[2]KPPs are attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability.

[3]An Operational Requirements Document (ORD) is a formatted statement containing performance and related operational parameters for the proposed concept or system. The V-22 is being developed under a joint-service ORD (JORD).

based on our audit objectives. An expanded version of the methodology used to conduct this audit may be found in Appendix I.

Results in Brief

As of January 2009, the 12 MV-22s in Iraq had successfully completed all missions assigned to them in what is considered an established, low-threat theater of operations.[4] The deployments confirmed the positive impact of the MV-22's enhanced speed and range, which enable squadrons to engage in general support missions and deliver personnel and internally carried cargo faster and farther than is possible with the legacy helicopters the MV-22 is replacing. The MV-22 was also called on to deliver external cargo a limited number of times, and participated in a few "AeroScout" missions.[5] However, some challenges in operational effectiveness were noted that have raised questions about whether the MV-22 is the aircraft best suited to accomplish the full mission repertoire of the Marine Corps helicopters it is intended to replace.[6] In addition, aircraft suitability challenges, such as unreliable parts and supply chain weaknesses, drove system availability below minimum required levels.[7] As a result, in Iraq, the three MV-22 squadrons averaged mission capability rates of about 68, 57, and 61 percent, while the minimum capability rate requirement is 82 percent.[8] In addition, the engines on the MV-22s deployed in Iraq fell short of their estimated "on-wing" service life.

[4]Low threat includes sporadic small arms fire from random locations (maximum caliber 7.62 mm / .30 cal), and automatic weapons (assault rifles). Medium threat includes those threats, plus larger caliber weapons (.50 cal / 12.5 mm and 23mm, but not Anti-Aircraft Artillery (AAA)) adapted for anti-aircraft fire, more sophisticated aiming devices, and legacy man-portable air-defense systems. High threat environment may include mobile and/or stationary surface-to-air missiles, early warning radars, integrated AAA fire control systems, and interceptor aircraft.

[5]AeroScout missions were developed for and conducted by legacy helicopters. The concept arose prior to the V-22 arriving in Iraq. AeroScout missions are made to identify suspicious targets and neutralize those threats.

[6]Operational Effectiveness is the measure of the overall ability of a system to accomplish a mission when used by representative personnel in the environment planned or expected for operational employment of the system.

[7]Operational Suitability is the degree to which a system can be placed and sustained satisfactorily in field use.

[8]The current requirement is for the V-22 program to attain the minimum required rate by the time the Marine Corps achieves 60,000 hours of V-22 flight time. The original requirement for the system did not, however, specify a flight hour limitation. As of February 2009, the Marines had logged in excess of 50,000 V-22 flight hours.

In addition to the Iraq experience, operational tests and training exercises have identified challenges with the MV-22's ability to operate in threat environments higher than existed during the MV-22's Iraq deployment. Maneuvering limits may affect air crew ability to execute the correct evasive action. Efforts to ready the MV-22 for deployment on Navy ships revealed that its large size and large inventory of repair parts created obstacles to shipboard operations. Furthermore, challenges have also been identified that could limit the MV-22's ability to conduct worldwide operations in some environments and at high altitudes similar to what might be expected in Afghanistan. While efforts are underway to address these challenges, it is uncertain how successful they will be, because some of these challenges are a consequence of the V-22's design.

Cost, schedule, and performance assumptions included in the V-22's original business case have eroded. The V-22's costs (stated in constant fiscal year 2009 dollars) have risen sharply above initial projections. Research, Development, Test & Evaluation (RDT&E) cost has increased over 200 percent, from $4.2 to $12.7 billion, due, in part, to development challenges. Total procurement costs also rose nearly 24 percent, from $34.4 to $42.6 billion, even though the program reduced its planned total procurement buy by about 50 percent, from nearly 1,000 to fewer than 500, most of which will be procured for the Marine Corps. The initial 1986 estimated procurement unit cost of $37.7 million each has increased by 148 percent to a 2007 estimate of $93.4 million each. To complete the total procurement, the program plans to request approximately $25 billion (in then-year dollars) for aircraft procurement. Furthermore, savings from using a multiyear procurement contract may be offset by costs to modify and upgrade already produced aircraft. The aircraft's operations and support costs, currently reported at $75.4 billion (then-year dollars) for the life cycle of the program, are just beginning and expected to rise. The MV-22's costs per flight hour is over $11,000—more than double the target estimate and 140 percent higher than the CH-46E helicopter.[9] Engine sustainment contract coverage for some repairs is excluded when engines are operated without the Engine Air Particle Separator (EAPS) turned on and for compressor repairs on deployed aircraft outside the United States

[9]Cost per flight hour is calculated by adding the total cost of fuel, flight equipment, consumables and repairables then dividing by the flight hours flown. Costs per flight hour for various aircraft should be considered in the context of their capabilities, missions flown, and actual usage.

regardless of EAPS operations.[10] A new sustainment contract is expected to be awarded after the current contract expires in December 2009, and is likely to result in higher engine sustainment costs and increased program support cost. Additionally, problems with parts reliability have resulted in more maintenance activity than expected, and if there is no improvement, overall cost and maintenance hours may remain high.

We are recommending that the Secretary of Defense re-examine the V-22 by requiring a new alternatives analysis to determine the most cost effective inventory of aircraft to meet the Marine Corps' current and future medium-lift needs, possibly to include other services' operational uses. This analysis should weigh V-22 capabilities and costs against other alternatives and should consider budgetary constraints.

Given the unresolved operational effectiveness and suitability issues and increasing costs associated with the V-22 system, we are also recommending that the Secretary of Defense require the Marine Corps to develop a prioritized strategy to improve system suitability (including identifying why measures such as component reliability and aircraft availability are low), reduce operational costs, and align future budget requests accordingly.

In its written comments, DOD concurred with our recommendation for the development of a prioritized strategy to improve system suitability, reduce operational costs, and align future budget requests accordingly. DOD non-concurred with our recommendation for a new V-22 alternatives analysis, stating that it supports validating required MV-22 quantities and the proper mix of aircraft. It would do so, however, through the annual review and update of the Marine Aviation Plan and not through a new V-22 alternatives analysis. We believe, however, that this recommendation remains valid—offering a fuller consideration of alternatives and assuring congressional decision makers that a reasoned business case exists that supports the planned acquisition of additional V-22 aircraft.

[10]This exception applies to engines installed and operated outside the United States in erosive/desert environments during the period of performance (April 2008 through December 2009).

Background

The V-22 Osprey is a tilt-rotor aircraft—one that operates as a helicopter for takeoffs and landings and, once airborne, converts to a turboprop aircraft—developed to fulfill medium-lift operations such as transporting combat troops, supplies, and equipment for the U.S. Navy, Marine Corps and Air Force special operations. Figure 1 depicts V-22 aircraft in various aspects of use.

Figure 1: Views of V-22 Aircraft in Various Aspects of Use

Source: U.S. Navy, U.S. Marine Corps.

There are two variants of the V-22's design. The Marine Corps variant (MV-22) was slated to replace the CH-46E and CH-53D helicopters (see figure 2) to become the Marine Corps' only medium-lift, assault support aircraft. Currently, the MV-22 is going to replace only the CH-46E. The Air Force variant (CV-22) will augment existing U.S. Special Operations Command (USSOCOM) aircraft.

Figure 2: CH-46 and CH-53 Helicopters

Source: U.S. Navy.

The Osprey program was started in December 1981 to satisfy mission needs for the Army, Navy, and Air Force. Originally spearheaded by the Army, the program was transferred to the Navy in 1982 when the Army withdrew from the program citing affordability issues. The program was approved for full-scale development in 1986, and the first aircraft was flown in 1989. A month after the first flight, the Secretary of Defense stopped requesting funds for the program due to affordability concerns. In December 1989, DOD directed the Navy to terminate all V-22 contracts because, according to DOD, the V-22 was not affordable when compared to helicopter alternatives, and production ceased. Congress disagreed with this decision, however, and continued to fund the project. Following a crash in 1991 and a fatal crash in 1992 that resulted in seven deaths, in October of 1992 the Navy ordered development to continue and awarded a contract to a Bell Helicopter Textron and Boeing Helicopters joint venture (Bell-Boeing) to begin producing production-representative aircraft.

In 1994, the Navy chartered a medium lift replacement COEA, which reaffirmed the decision to proceed with the V-22. It also provided an analytical basis for KPPs to be proposed for the system. This analysis defined the primary mission of a medium-lift replacement aircraft to be the transport of combat troops during sea-based assault operations and during combat operations ashore. Secondary missions included transporting supplies and equipment during assault and other combat operations as well as supporting Marine Expeditionary Unit (MEU) special operation forces, casualty and noncombatant evacuation operations, tactical recovery of aircraft and personnel operations, combat search and rescue operations, and mobile forward area refueling and re-arming operations. These original mission descriptions and aircraft employment were reaffirmed by the Marine Corps in 2003 and again in 2007. The existing medium-lift aircraft fleet needed to be replaced due to inventory shortfalls

and reduced aircraft reliability, availability, and maintainability—needs accentuated by the increasing age and limited capabilities of its current fleet of helicopters.

The analysis concluded that the V-22 should be the Marine Corps' choice. The analysis considered a number of helicopter candidates—including the CH-46E and CH-53D—and the V-22 tiltrotor—judging each candidate based on their performance characteristics and expected contribution to tactics and operations. A sensitivity analysis was conducted which measured candidate aircraft against specific performance parameters—including KPPs. The analysis used models to assess research and development, production or procurement, and operations and support cost and concluded that for non-assault missions, such as medical evacuation missions, the V-22 was the most effective option because of its greater speed, increased range, and ability to deploy in one-third the time of the alternative candidates. For assault missions, the analysis concluded the V-22 would build combat power in the form of troops and equipment most quickly, was more survivable, would maximize the arrival of forces and minimize casualties, and would halve helicopter losses. In terms of affordability, the analysis concluded that, holding V-22 and helicopter force sizes equal, the V-22 would be the most effective but at a higher cost. The analysis further noted that while the major factor in favor of the V-22 was its speed, at short distances greater speed offers little advantage.

Subsequently, Low-Rate Initial Production (LRIP) began with five aircraft in 1997, increasing to seven each year in 1998 and 1999. In 2000, the program undertook operational evaluation testing, the results of which led the Navy's operational testers to conclude that the MV-22 was operationally suitable for land-based operations and was operationally effective. Later evaluations resulted in testers concluding that the MV-22 would be operationally suitable on ships as well. Based on the same tests, DOD's independent operational testers concluded that the MV-22 was operationally effective but not operationally suitable, due in part to reliability concerns. Despite the mixed test conclusions, a Program Decision Meeting was scheduled for December 2000 to determine whether the V-22 should progress beyond LRIP production and into full-rate production. Following two fatal crashes that occurred in 2000 and resulted in 23 deaths, the last one occurring just before the full-rate production decision, the V-22 was grounded and, rather than proceeding to full-rate production, the program was directed to continue research and development at a minimum sustaining production rate of 11 aircraft per year.

Before the V-22 resumed flight tests, modifications were made to requirements and design changes were made to the aircraft to correct safety concerns and problems. The aircraft nacelles[11] were redesigned to preclude line chafing; a robust software qualification facility was built; and Vortex Ring State, a dangerous aerodynamic phenomenon that all rotor wing aircraft are subject to and was reported to have contributed to one of the fatal V-22 crashes in 2000, was further investigated.[12] Requirements for landings in helicopter mode in which engine power had failed ("autorotation") and nuclear, chemical and biological weapons protection among others were eliminated, and some KPPs were modified, prior to conducting a second round of operational testing with modified aircraft in June 2005.[13] Testers then recommended that the aircraft be declared operationally effective and suitable for military use. The Defense Acquisition Board approved it for military use as well as full-rate production in September 2005. DOD is procuring the V-22 in blocks. Block A is a training configuration, while later blocks are being procured and fielded as the operational configurations. Tables 1 and 2 provide a summary of the upgrades to be incorporated in each block configuration.

[11]The nacelle houses the engine, accessories, engine-driven gearbox, and rotor drive system. It also includes flexible and rigid hydraulic lines, proprotor flight control system actuators and critical mechanical components.

[12]Vortex Ring State (VRS) or "power settling" is a phenomenon in which the combination of low forward speed and high rate of descent causes the upward flow of air around a rotor to approach the same velocity as the downwash produced by the rotor. When this happens, the rotor loses lift.

[13]See page 28 which discusses KPP modifications in more detail.

Table 1: MV-22 Block Upgrade Definitions

Block	Description
Block A	This upgrade includes those efforts necessary to return the MV-22 to safe and operational fleet operations. This aircraft represents the core Fleet Marine Force aircraft. These improvements will include a redesign of hydraulic tubing and electrical wiring in the engine nacelles, upgraded flight control software, and Reliability and Maintainability (R&M) improvements. Capabilities are defined in the Joint Requirements Oversight Council (JROC)-approved CPD.
Block B	This upgrade provides correction of deficiencies identified in previous operational tests. Improved maintenance access to the engine nacelle, avionics and cockpit upgrades, hoist and defensive weapons system capabilities are also included. Capabilities are defined in the JROC-approved CPD.
Block C	This upgrade incorporates mission enhancements while continuing to provide R&M improvements. The improvements include but are not limited to enhancements in communication, navigation, net-readiness and interoperability.
P^3I	These upgrades will continue to build on the existing blocks. Pre-Planned Product Improvements (P3I) include maturing technologies to improve R&M and further expand capabilities.

Source: JROC Approved 2007 V-22 Capability Development Document.

Table 2: CV-22 Block Upgrade Definitions

Block	Description
Block 0	Provide basic special operations capability to the V-22 Osprey Tiltrotor by adding a self-protection Electronic Counter Measures suite, Terrain Following/Terrain Avoidance radar, and communications interoperability with other Special Operations Forces, as well as correction of deficiencies.
Block 10	Provides improved Special Operations capability to the V-22 by adding countermeasures capabilities.
Block 20	Provides growth and expanded Special Operations capability to the V-22 while continuing to provide R&M improvements.
Block 30	Provides growth in net-readiness and interoperability. Incorporates an advanced special operations forces radar.
P^3I	These upgrades will continue to build on the existing blocks. Pre-Planned Product Improvements (P3I) include maturing technologies to improve R&M and further expand capabilities.

Source: JROC Approved 2007 V-22 Capability Development Document.

The MV-22 Block B attained Initial Operational Capability (IOC) in June 2007 and was used in Iraq from October 2007 until April 2009 to support operations from Al Asad Air Base in Iraq's Anbar province. Three Marine squadrons used the same 12 MV-22s for three consecutive deployments.[14] In March 2008, the Navy awarded Bell-Boeing a 5-year, $10.4 billion production contract for 141 MV-22s and 26 CV-22s. This multiyear contract was awarded to achieve anticipated procurement cost savings. In 2008, after undergoing operational testing, 4 Air Force variant CV-22s self-deployed to participate in a multinational training effort in a remote

[14]Those three squadrons are VMM-263 (October 2007 to March 2008), VMM-162 (April 2008 to September 2008) and VMM-266 (October 2008 to April 2009).

location in Mali, and were used to conduct simulated long-range air-drop and extraction missions. The first shipboard deployment of MV-22s is scheduled for mid-2009.

MV-22 Operations in Iraq Demonstrated Effectiveness for Assigned Missions but the Aircraft Continues to Experience Challenges

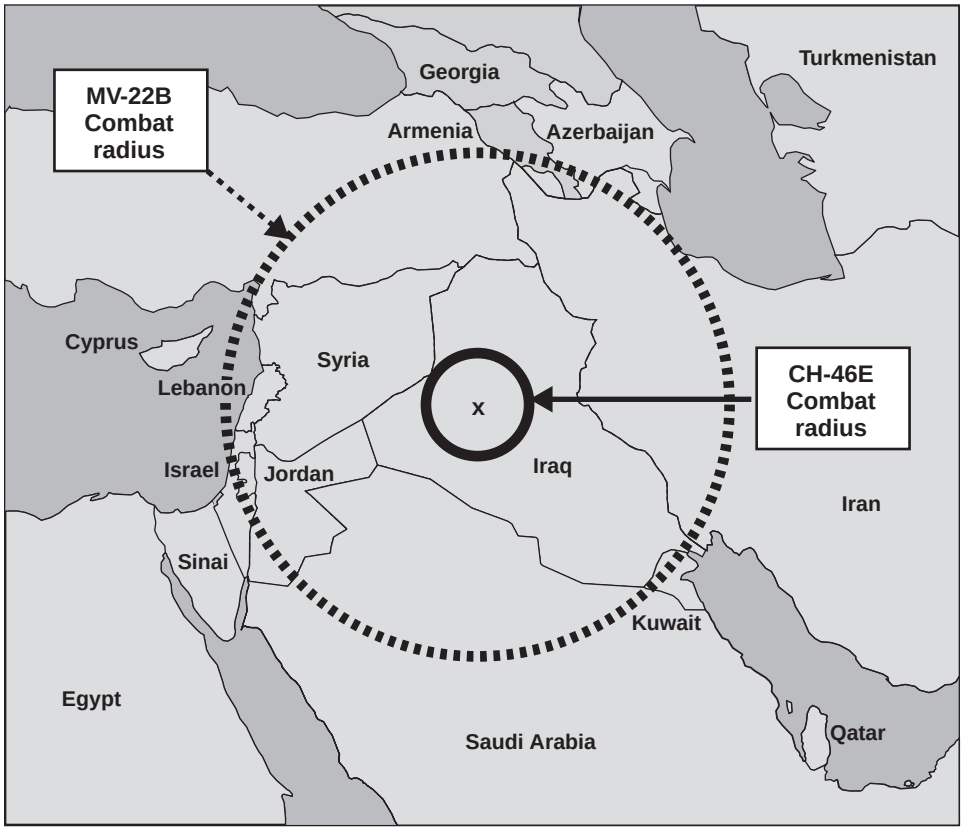
As of January 2009, the 12 MV-22s stationed in Iraq had successfully completed all missions assigned to them in what is considered an established, low-threat theater of operations. The deployments confirmed that the V-22's enhanced speed and range enable personnel and internal cargo to be transported faster and farther than is possible with the legacy helicopters it is replacing. The aircraft also participated in a few AeroScout missions and carried a limited number of external cargo loads. However, questions have arisen as to whether the MV-22 is best suited to accomplish the full mission repertoire of the helicopters it is intended to replace. Some challenges in operational effectiveness have been noted. Also, suitability challenges, such as unreliable parts and an immature parts supply chain drove availability significantly below minimum required levels.[15]

The MV-22 Successfully Completed Assigned Missions in Iraq, Although Some Operational Challenges Were Identified

The Marine Corps considers the MV-22 deployments in Iraq to have been successful, as the three squadrons consistently fulfilled assigned missions. Those missions were mostly general support missions—moving people and cargo—in the low-threat operational environment that existed in Iraq during their deployments. The aircraft's favorable reviews were based largely on its increased speed and range compared with legacy helicopters. According to MV-22 users and troop commanders, its speed and range "cut the battlefield in half," expanding battlefield coverage with decreased asset utilization and enabling it to do two to three times as much as legacy helicopters could in the same flight time. In addition, the MV-22's ability to fly at higher altitudes in airplane mode enabled it to avoid the threat of small arms fire during its Iraq deployment. Figure 3 compares the flight radius of the MV-22 to that of legacy CH-46s.

[15]Suitability—comprised of maintainability, reliability, and availability – is the degree to which a system can be placed and sustained satisfactorily in field use.

Figure 3: Comparison of MV-22 to CH-46E Combat Radius



Source: GAO map based on USMC data; Map Resources, (map).

Commanders and operators have noted that the speed and range of the Osprey offered some significant advantages over the legacy platforms it replaced during missions performed in Iraq, including missions that would have been impossible without it. For example, it enabled more rapid delivery of medical care; missions that had previously required an overnight stay to be completed in a single day; and more rapid travel by U.S. military and Iraqi officials to meetings with Iraqi leaders, thus allowing greater time for those meetings.

While in Iraq, the MV-22 also conducted a few AeroScout raid and external lift missions. These types of missions were infrequent, but those that were carried out were successfully completed. Such missions, however, were also effectively carried out by existing helicopters. AeroScout missions are made by a combination of medium-lift aircraft and attack helicopters with a refueling C-130 escort that, according to Marine Corps officers, find

suspicious targets and insert Marines as needed to neutralize threats. In participating in these missions, the MV-22 was limited by operating with slower legacy helicopters—thus negating its speed and range advantages. Similarly, external lift missions do not leverage the advantages of the V-22. In fact, most Marine equipment requiring external transport is cleared only for transit at speeds under 150 knots calibrated airspeed (kcas), not the higher speeds at which the MV-22 can travel with internal cargo or passengers. According to Iraq-based MV-22 squadron leadership, the CH-53, which is capable of lifting heavier external loads, was more readily available than the MV-22 to carry out those missions and, as such, was generally called on for those missions, allowing the MV-22 to be used more extensively for missions that exploit its own comparative strengths.

The introduction of the MV-22 into Iraq in combination with existing helicopters has led to some reconsideration of the appropriate role of each. Battlefield commanders and aircraft operators in Iraq identified a need to better understand the role the Osprey should play in fulfilling warfighter needs. They indicated, for example, that the MV-22 may not be best suited for the full range of missions requiring medium lift, because the aircraft's speed cannot be exploited over shorter distances or in transporting external cargo. These concerns were also highlighted in a recent preliminary analysis of the MV-22 by the Center for Naval Analysis, which found that the MV-22 may not be the optimal platform for those missions.

The MV-22's Iraq experience also demonstrated some limitations in situational awareness that challenge operational effectiveness. For example, some MV-22 crew chiefs and troop commanders in Iraq told us that they consider a lack of visibility of activity on the ground from the V-22's troop cabin to be a significant disadvantage—a fact previously noted in operational testing. They noted that the V-22 has only two small windows. In contrast, combat Marines in Iraq stated that the larger troop compartment windows of the CH-53 and CH-46 offer improved ability to view the ground, which can enhance operations. In addition, CH-53s and CH-46s are flown at low altitude in raid operations. According to troop commanders this low altitude approach into the landing zones combined with the larger windows in CH-53s and CH-46s improves their (the troop commanders) situational awareness from the troop compartments, compared with the situational awareness afforded troop commanders in the MV-22s with its smaller windows and use of high altitude fast descent approach into the landing zone. The V-22 program is in the process of incorporating electronic situational awareness devices in the troop cabin to off-set the restricted visibility. This upgrade may not fully address the

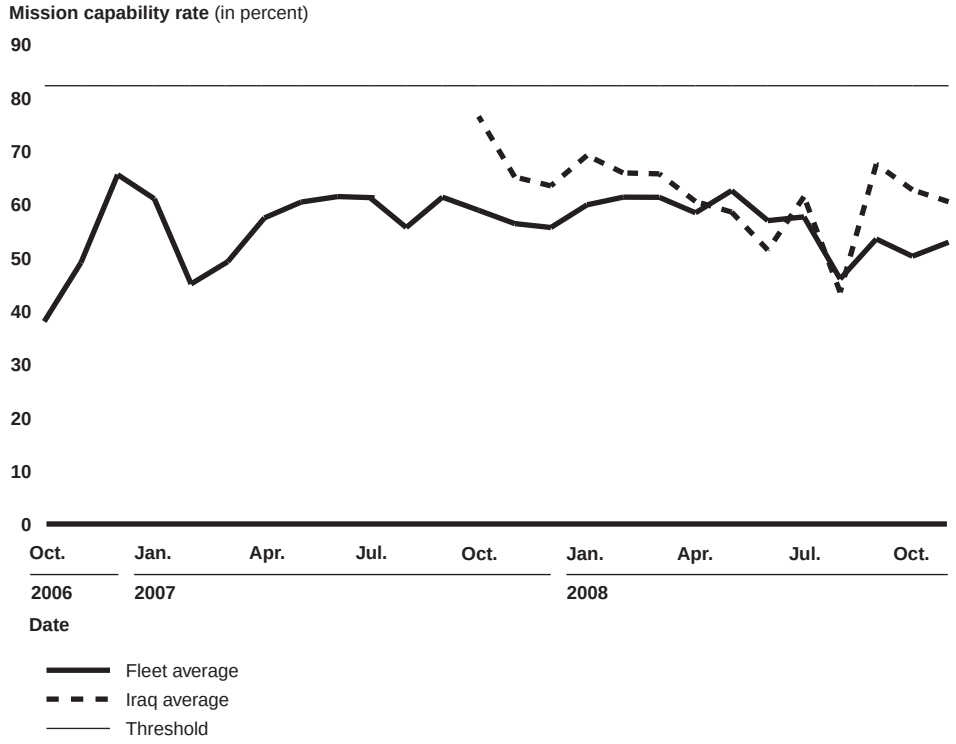
situational awareness challenges for the crew chief, who provides visual cues to the pilots to assist when landing. Crew chiefs in Iraq agree that the lack of visibility from the troop cabin is the most serious weakness of the MV-22.

Iraq Deployment Demonstrated Continuing Suitability Challenges

Availability challenges continue to affect the MV-22. In Iraq, the V-22's mission capability (MC) and full mission capability (FMC) rates fell significantly below required levels and significantly below rates achieved by legacy helicopters.[16] The MV-22 has a stated MC threshold (minimum acceptable) requirement of 82 percent and an objective (desired) of 87 percent. In Iraq, the three MV-22 squadrons averaged mission capability rates of about 68, 57, and 61 percent respectively. This experience is not unique to the Iraq deployment, as low MC rates were experienced for all MV-22 squadrons, in and out of Iraq. The program has modified the MC requirement by stating that this threshold should be achieved by the time the fleet completes 60,000 flight hours, which officials expect to occur sometime near the end of 2009. Figure 4 illustrates the MC rates between October 2006 and October 2008.

[16]An aircraft that is mission capable (MC) is one that is in a material condition to perform at least one of its designated missions, while an aircraft that is fully mission capable (FMC) is in a material condition to perform all of its designated missions.

Figure 4: MV-22 Mission Capability Rates between October 2006 and October 2008



Source: GAO analysis of U.S. Navy data.

By comparison, the mission capability rates of the Iraq-based CH-46Es and CH-53s averaged 85 percent or greater during the period of October 2007 to June 2008.

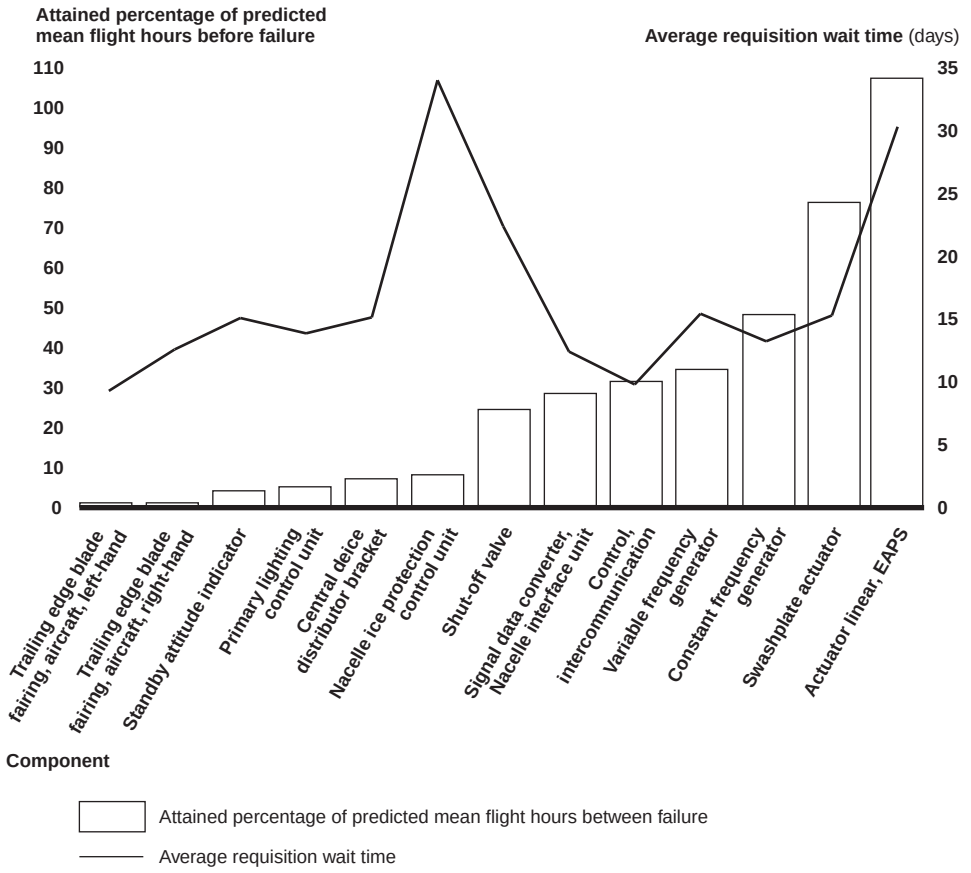
Although FMC is no longer a formal requirement, it continues to be tracked as an indicator of aircraft availability. The Osprey's FMC rate of 6 percent in Iraq from October 2007 to April 2008 was significantly short of the 75 percent minimum requirement established at the program's outset. According to MV-22 officers and maintainers, the low FMC rate realized was due in part to unreliability of V-22 Ice Protection System (IPS) components. Although the faulty IPS had no effect on the MV-22's ability to achieve missions assigned in Iraq, in other areas, where icing conditions are more likely to be experienced—such as Afghanistan—IPS unreliability may threaten mission accomplishment.

Repair Parts Issues and Maintenance Challenges Affected the Availability of MV-22s in Iraq

Although MV-22 maintenance squadrons stocked three times as many parts in Iraq as the number of deployed MV-22 aircraft called for, they faced reliability and maintainability challenges. Challenges were caused mostly by an immature parts supply chain and a small number of unreliable aircraft parts, some of which have lasted only a fraction of their projected service life.

The MV-22 squadrons in Iraq made over 50 percent more supply-driven maintenance requests than the average Marine aviation squadron in Iraq. A lack of specific repair parts was a problem faced throughout the Iraq deployments despite deploying with an inventory of spare parts to support 36 aircraft, rather than the 12 MV-22 aircraft actually deployed. Despite the preponderance of parts brought to support the MV-22s in Iraq, only about 13 percent of those parts were actually used in the first deployment. In addition, some aircraft components wore out much more quickly in Iraq than expected, which led to shortages. Thirteen MV-22 components accounted for over half the spare parts that were not available on base in Iraq when requested. Those components lasted, on average, less than 30 percent of their expected life, with six lasting less than 10 percent of their expected life. The shortages caused MV-22 maintainers to cannibalize parts from other MV-22s to keep aircraft flying, and significantly increased maintenance hours. Parts were cannibalized not only from MV-22s in Iraq but also from MV-22s in the United States and from the V-22 production line. The shortages also contributed to the low mission capability rates, as an aircraft in need of maintenance or spare parts may not be considered mission capable. Figure 5 depicts both the percentage of predicted mean flight hours before failure achieved by these 13 parts and their average requisition waiting time during the Iraq deployments.

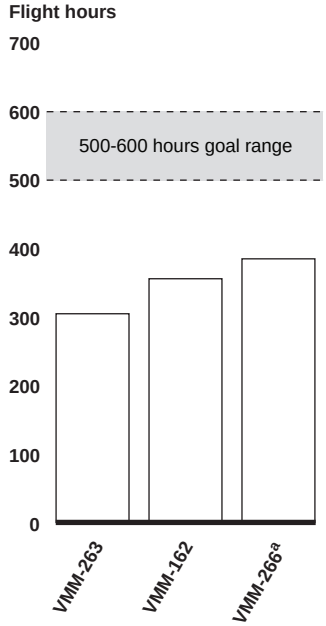
Figure 5: Attained Percentage of Predicted Mean Flight Hours before Failure and Requisition Wait Time for Top 13 Parts Degrading MV-22 Mission Capability



Source: GAO analysis of U.S. Marine Corps data.

The engines on the MV-22s deployed in Iraq also fell short of their estimated "on-wing" service life, lasting less than 400 hours before having to be replaced. The program estimated life is 500-600 hours. The program office noted that there is no contractually documented anticipated engine service life. Figure 6 illustrates the average engine time on wing for the three MV-22 squadrons that have been deployed to Iraq.

Figure 6: Iraq-Deployed MV-22 Squadrons' Average Engine Time on Wing



Source: GAO analysis of U.S. Navy data.

[a]Data for VMM-266 squadron represent only a portion of the ongoing deployment.

Squadron maintainers explained that the lower engine life span has not affected aircraft availability, as spare engines are readily available and easily replaced. Program officials plan to replace the existing power-by-the-hour engine sustainment contract with Rolls Royce, which expires in December 2009, with a new sustainment contract.[17] According to the program office, the new engine sustainment contract is likely to result in higher engine support costs—an issue further discussed later in this report.

[17]Under a power-by-the-hour arrangement, the contractor provides fixed-cost maintenance based on the number of hours flown each year. Using this concept, the customer provides a fixed level of funding and expects, subject to some exclusions, to receive a given level of support by the contractor. The contractor expects to be provided a fixed level of funding up front and anticipates a long-term support arrangement.

Operational Tests and Training Exercises Have Revealed Other Challenges to the MV-22 in Accomplishing Its Full Range of Possible Operations

While the MV-22 successfully accomplished missions assigned to it in Iraq, those missions represent only a portion of the operations envisioned for the system. Operational tests and training exercises have provided additional insights into the aircraft's capabilities and have identified challenges to the MV-22's ability to conduct operations in high-threat environments, carry the required number of combat troops, transport external cargo, operate from Navy ships, and conduct missions operating in environments throughout the world. While efforts are underway to address these challenges, how successful they will be is uncertain, as some challenges arise from the inherent design of the V-22.

MV-22 Faces Challenges in Operating in High-Threat Environments

The Osprey was intended to operate across the full spectrum of conflicts, facing a broad range of enemy land- and sea-based weapons. Although the Iraq deployments validated the ability of the MV-22 to conduct missions in Iraq's low-threat environment, its ability to conduct operations and survive in higher threat environments is less certain. Maneuvering limits may affect air crew ability to execute the correct evasive action. Currently, the Marine Corps intends to employ the aircraft in a manner that limits its exposure to threats—a change from the original intent, that the system would be able to operate in such environments. In addition, the MV-22 does not have an integrated defensive weapon, a system requirement.

Although the speed, range, and altitude capabilities of the MV-22 reduce its overall susceptibility to threats as compared to legacy transport helicopters, operational testers identified flight limits that restrict the aircraft's flight parameters and could influence its ability to respond to threats. Restricted maneuverability limits its ability to perform defensive maneuvers. Flight limits have been imposed while the aircraft is in helicopter mode to avoid a loss of controlled flight.

Limits have been imposed to avoid Vortex Ring State (VRS), a condition that can cause a loss of lift and control of the aircraft when it is in helicopter mode. VRS can occur in any rotorcraft, and in the V-22 is now considered well defined and avoidable when the aircraft's forward speed and descent rate stay within prescribed ranges. However, specifically in the V-22, VRS can result in loss of lift on one proprotor and not the other, causing the aircraft to invert. Testers previously recommended that follow-on tests should involve multiple aircraft, at heavy weights, in close proximity as might be anticipated in the conduct of a combat assault mission. The test could increase confidence that appropriate, safe tactics exist to enable the MV-22s to deliver assault forces to a small area in a short time while avoiding undue exposure to enemy threats.

Although an integrated defensive weapon system—needed to suppress threats while approaching a landing zone, disembarking troops within the landing zone, or while leaving the landing zone—is a requirement, the MV-22 does not have such a system. The MV-22 currently has only a rear ramp-mounted defensive weapon system that is not integrated into the aircraft and only covers its rear quadrants. Based on Iraq experiences, this defensive weapon was viewed as lacking flexibility due to its ability to only point in one direction when employed in the "ground fire" position and because it was not of sufficient caliber to be effective in all scenarios. Some air crews commented that the capabilities of the MV-22 offset previous notions about the requirement for defensive fire power. However, commanders stated that while the current defensive weapon system was sufficient for the Iraq deployment, many other scenarios are easily envisioned where an improved defensive weapon system would be much preferred. A belly-mounted Interim Defensive Weapon System (IDWS) capable of covering all quadrants is being tested. However, in tests, the system jammed frequently. Additionally, it will not be fully integrated into the aircraft systems and is not currently compatible with the shipboard environment. Furthermore, integration of the IDWS into MV-22s will result in a loss of two combat troop seats to accommodate the IDWS avionics rack.

MV-22 Faces Challenges in Capacity to Transport Personnel and External Cargo

Additional missions for the MV-22 include internal and external transport of supplies and equipment during assault and other combat operations. Operational tests and shipboard training exercises have determined that the capacity of the MV-22 to transport troops and external cargo is, in some cases, below program requirements.

The ability to transport 24 troops equipped with a full combat load is a key performance parameter for the MV-22. While officials and Marine combat units who have flown in the MV-22 say it can carry 24 troops, a Marine Corps after-action report indicates that the MV-22 can not carry 24 troops if they are equipped as intended. The MV-22 operational requirements document based the 24 troop number for the MV-22 variant on an assumption of an average weight for a fully equipped combat troop of 240 pounds; however, improvements in body armor and equipment have raised the weight projection for each Marine with combat equipment to 400 pounds. As a result, the aircraft's planned capacity to transport fully loaded combat troops is 20 rather than 24.

Aircraft troop-carrying capacity may be further reduced in other configurations and flight scenarios. As previously stated, the belly-

mounted interim defensive weapon system will reduce the number of combat troops that can be transported by two. When the platoon of Marines transported is configured with heavy weapons, the number of embarked troops may be reduced due to limited cabin volume. Further, according to a crew chief interviewed, when combat loads placed in the aisle restrict crew chief movement, a second crew chief may be needed to guide aircraft landings, reducing troop capacity. Figure 7 illustrates troops embarked in the MV-22 troop compartment.

Figure 7: MV-22 Troop Compartment

Source: U.S. Marine Corps document, *MV-22B Capabilities and Planning Considerations.*

External transport of cargo is another requirement of the MV-22. However, most external loads have not been certified by DOD for high-speed transport and thus would not leverage the V-22's speed. Furthermore, according to a 2007 Center for Naval Analysis study, the MV-22 will not be able to externally transport heavier equipment, such as the Joint Light Tactical Vehicle—which is to replace the Marine Corps Humvee. The study concluded that there would be less need to use the MV-22s for external lifting and an increased requirement for heavier lift helicopters, such as the CH-53K.

Additionally, the program manager is currently tracking the projected weight growth of the MV-22 Block C variant, and considers weight growth a moderate risk to the program. External lift capability is likely to be diminished if the weight of the MV-22 platform exceeds projected weight growth. Furthermore, according to the MV-22 flight operations manual, the current 10,000-pound maximum lift capacity of the MV-22 is achievable at lower altitudes, but is reduced at higher altitudes. Weight growth in the aircraft itself would further reduce the aircraft's operational ability to transport loads into higher altitude regions of the world, such as Afghanistan.

MV-22 Faces Challenges Operating on Navy Ships

Efforts to ready the MV-22 for deployment on Navy ships identified numerous challenges. Fewer MV-22s can operate on Navy flight decks. Its larger size and large inventory of repair parts constrain hangar deck space. In addition, safety concerns caused by its severe rotor downwash have been documented during MV-22 ship-based testing and land-based testing of the CV-22 variant.

The MV-22 is too large to operate in the same numbers (without altering the ship's current aviation complement) from ships certified for the CH-46 and CH-53 aircraft, including LHA- or LHD-class ships.[18] The MV-22 has a larger footprint than the CH-46, reducing the number of aircraft that can be deployed on board any one ship. For example, the 22nd MEU will deploy with 10 MV-22s rather than 12 CH-46s that previously deployed with the same ship. Furthermore, MV-22 deck spot utilization also differs from that of the CH-46: the aircraft is not cleared to take off and land using the two deck spots adjacent to the tower of LHA- and LHD-class ships. As a result, the MV-22 is only cleared to take off and land from four of the six operational deck spots of the LHD- and LHA-class ships usable by CH-46s. According to program officials, efforts are underway to try to approve operational use of these deck positions for takeoff and landing on LHD ships.

The repair parts inventory that a squadron of MV-22s deploys with is significantly greater in volume and weight than that of the legacy helicopters it is replacing and will impinge on maintenance and other

[18]LHA and LHD ships are the amphibious assault ships designed to transport and land troops and essential combat equipment and supplies by aircraft, amphibious craft, and vehicles.

operations in the ship's hangar space. The space needed for MV-22 repair parts is so large that some parts may need to be pre-positioned ashore and not housed shipboard. Hangar space is used to conduct maintenance on aircraft sheltered from the elements or if the maintenance effort requires the use of heavy lifting cranes located in the hangar deck ceiling. Training exercises found that the larger MV-22 reduced the number of spots that can be used in the hangar deck for maintenance from four to three, and made movement of aircraft from the hangar deck to the flight deck difficult if an MV-22's wings were spread or an aircraft was on jacks undergoing repairs.

The MV-22's downwash has been described as significantly greater than that of the CH-46. During prior operational tests, concerns were raised about the effect of downwash on operations below the aircraft, including troop embarkation and debarkation, hooking up external loads, and fastroping.[19] Recent shipboard tests have identified safety issues related to MV-22 downwash, including dislodging equipment such as life raft securing bands, and potentially blowing down the sailor who stands on the flight deck of the ship guiding the aircraft to a safe landing. To resolve these problems, life raft containers have been replaced through ship alterations with containers intended to withstand the downwash, and, during one training exercise on an L-class ship, another person was assigned to physically hold in place the sailor acting as the landing guide when MV-22s were landing. Downwash of the MV-22 interacting with other aircraft was also noted onboard ship. In one documented incident, downwash from a landing MV-22 exerted such force on the helicopter next to it that the helicopter's pilot had to take action to prevent his aircraft from lifting off the ship. Downwash concerns, however, are not restricted to shipboard operations. Recently completed tests on the CV-22 found that the significant downwash also had various negative effects on the land-based missions.

Challenges Operating Globally in Extreme Environments

At the start of its development, the V-22 was intended to operate in many different environments. However, its current capability to conduct worldwide operations in many environments is limited. It is not able to conduct unrestricted operations in tactical nuclear, biological, and chemical (NBC) warfare; at high altitudes; or in adverse weather.

[19]Fastroping is a method used by troops to quickly exit a hovering aircraft.

For example, the V-22 had a requirement that its fuselage and cockpit design must restrict the entry of NBC contaminants into the aircraft and must protect and isolate the primary flight crew during ground operations. During developmental testing, numerous problems were encountered with the seals intended to maintain the cabin pressure, so the system was not used in operational testing in 2000. In the absence of such a system, the DOD Director, Operational Test and Evaluation found that operational MV-22s would be forced to avoid or exit areas of suspected nuclear, biological, or chemical contamination and require time to decontaminate affected aircraft—likely reducing their availability and sortie capability. The NBC requirement has since been dropped.

The MV-22 is intended to be capable of supporting diverse mission requirements that will require it to fly during the day or at night, in favorable or adverse weather, across a range of altitudes from close to the ground to above 10,000 feet above mean sea level and to make numerous takeoffs and landings on different and difficult terrain conditions. Current V-22 performance charts do not support helicopter operations above 10,000 feet. Furthermore, according to recent MV-22 tests, the V-22's IPS is not reliable. Flying through known or forecasted icing conditions is currently prohibited. The status of the IPS is one of the main issues preventing the MV-22 from being fully mission capable. Additionally, the MV-22 currently does not have weather radar. Incorporation of weather radar into a later Block upgrade is planned to give the aircraft the ability to fly in other adverse weather conditions that may be encountered.

V-22 Business Case Challenged as Costs Have Risen While Performance Requirements Have Been Modified

The V-22 entered development with performance requirements and expected costs that constituted a business case for starting the program. The original program cost estimates have changed significantly as research and development and procurement costs have risen sharply above initial projections. With regard to operations and support costs for the V-22, the current Flying Hour Program (FHP) cost per flight hour of the MV-22 today is over $11,000—more than double the target estimate and 140 percent higher than the cost for the CH-46E. Furthermore, performance standards and metrics for V-22 were modified throughout the development effort.

V-22 Business Case and Acquisition Strategy Have Eroded as Costs Have Increased Significantly and Are Expected to Continue to Rise

From the start of initial development in 1986 through the end of 2007, the program's RDT&E cost increased over 200 percent from $4.2 to $12.7 billion, while its procurement cost increased nearly 24 percent from $34.4 to $42.6 billion.[20] This increase in procurement cost occurred at the same time that the number of aircraft to be procured was significantly reduced—from nearly a thousand to less than 500 (most of which will be procured for the Marine Corps), resulting in a 148 percent increase in procurement unit cost for each V-22. Furthermore, operations and support (O&S) cost will be higher than anticipated. Table 3 details key aspects of the V-22 program's cost and schedule experience from development start to 2007.

Table 3: V-22 Cost, Quantity and Schedule Changes from Development Start to 2007

Costs in millions of constant fiscal year 2009 dollars			
	1986	**2007**	**Percentage Change**
R&D	$4,211.8	$12,682.0	201%
Procurement	$34,362.9	$42,585.2	24%
Procurement unit cost	$37.7	$93.4	148%
Average program unit cost (RDT&E plus procurement)/Quantity	$42.3	$121.2	186%
Procurement quantities	913	456	-50.1%
Production years	1990-1999	1997-2018	
Initial operational capability	1992	June 2007	

Source: GAO analysis of U.S. Navy V-22 Selected Acquisition Reports.

In March 2008, the Navy awarded a 5-year procurement contract with the expectation of achieving a savings of $427 million for a buy of 167 aircraft.[21] To complete the total procurement, the program plans to request approximately $25 billion (in then-year dollars) for aircraft procurement beyond the $29 billion already appropriated and planned for development and procurement. Design changes to the V-22 to address identified shortcomings and reflect other upgrades to the aircraft continue—even as the V-22 is in production—will incur costs that may offset savings from the multiyear procurement contract. Design changes and increased procurement and retrofit costs can be expected, such as the $107.8 million

[20]Amounts are in constant fiscal year 2009 dollars.

[21]Savings have been included in applicable lot aircraft prices.

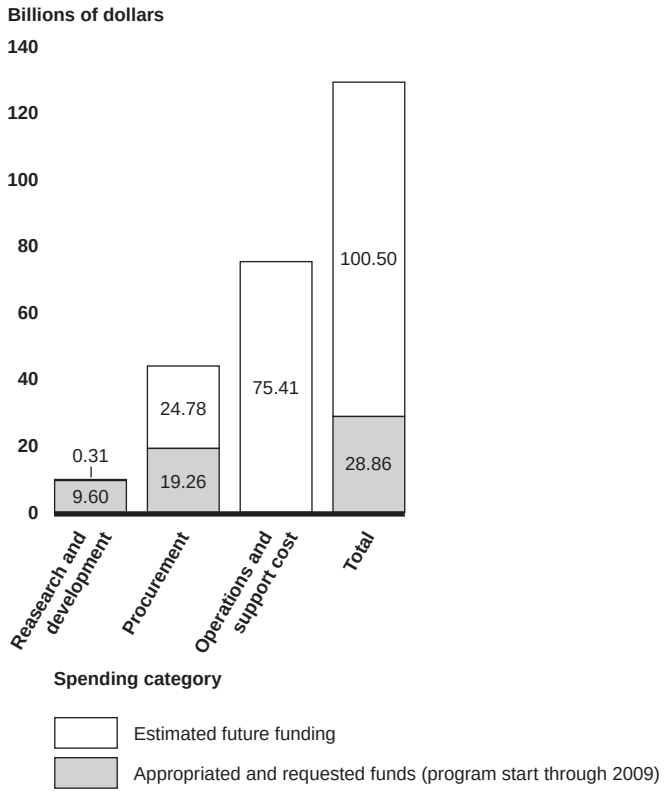
requested in the fiscal year 2008 Global War on Terrorism budget for the correction of deficiencies and upgrades to aircraft already produced.

Operations and Support Cost for the MV-22 Will Be Higher Than Anticipated

Operations and support (O&S) cost—typically the largest portion of a weapon system's total costs—are currently reported at $75.41 billion for the life cycle of the program. O&S costs for the program are just beginning and are expected to rise. An indication is the current cost per flying hour, which is over $11,000—more than double the target estimate for the MV-22 as well as 140 percent higher than the cost for the CH-46E.[22] The Osprey's Iraq experience demonstrated that the rise in cost is due in part to unreliable parts, the cost of some parts, and required maintenance. Figure 8 shows the program's current funding profile.

[22]These data were gathered after the Material Support Date, October 1, 2008, when the Navy assumed responsibility for all spares and repair parts needed to support a new weapons system, subsystem, or support equipment end item at Fleet operational sites.

Figure 8: V-22 Funding Profile (Then-Year Dollars)



Source: *V-22 December 2007 Selected Acquisition Report*.

Note: O&S expenditures to date for the recently fielded MV-22 are not reported in the Selected Acquisition Report. O&S funding represents past and future funding needs. In fiscal year 2009 dollars, R&D would be $12.6 billion in past funds and $0.3 billion in estimated future funding; procurement would be $21 billion in past funds and $22.3 billion estimated future funding, and O&S would be $54.5 billion in estimated future funding.

According to Marine Corps officials, the presence of unreliable parts contributed to reliability and maintainability issues for MV-22 deployed in Iraq. The inventory of repair parts needed to maintain the MV-22 is large. Although the squadrons in Iraq were supported with a parts inventory large enough for three times the number of aircraft deployed, certain "high-demand, low-density items" were used and their spare inventories depleted—driving the need for expensive and time-consuming cannibalization of repair parts from other aircraft. A reliability and maintainability program is in place to address underperforming components. Efforts include a recently awarded joint performance-based logistics contract to identify ways to improve aircraft reliability and reduce the system's logistics footprint. However, program management does not

consider the current reliability and maintainability strategy to be coherent. Problems with parts reliability have resulted in more maintenance activity than expected, and if there is no improvement, overall cost and maintenance hours may remain high.

Changes to the current engine sustainment contract with Rolls Royce—the V-22's engine manufacturer—could also affect the program's already rising O&S costs. The government initially decided to use a commercial engine and support approach. According to contractor officials, the billing arrangement for the V-22 engine "power-by-the-hour" sustainment contract with Rolls-Royce was originally based on complicated models that attempted to estimate the degree of engine degradation that might take place in a given number of flight hours, depending on the nature of the mission. However, the MV-22 engines in Iraq are not lasting as long as expected, and according to the program office, a new sustainment contract is being negotiated with Rolls Royce.

In March 2008, a modification to the original contract with an option for a 1 year extension was awarded—changing the original billing arrangement. According to contractor officials, under this bridge contract, engine sustainment billing is now to be based on a straight flight hour basis. Contract coverage for some repairs are excluded when engines are operated without the Engine Air Particle Separator (EAPS) turned on and for compressor repairs on deployed aircraft outside the United States regardless of EAPS operations.[23] Currently the excluded coverage accounts for 47 percent of total engine support cost. In addition, the bridge contract expires in December 2009 and the power-by-the-hour arrangement is expected to be replaced by a new sustainment contract. According to the program office, this new sustainment contract is likely to result in higher engine sustainment costs and increased program support cost.

Key Performance Standards and Other Performance Metrics for MV-22 Modified

Initially, the Marine Corps' proposed performance parameters for the medium lift replacement (MLR) aircraft were focused on speed, range, and payload. However, the Joint Requirements Oversight Council deferred consideration of system requirements until after completion of the 1994 Cost and Operational Effectiveness Analysis (COEA) that validated the V-

[23]The exception applies to engines installed and operated outside the United States in erosive/desert environments during the period coverage.

22 over other alternatives. Some KPPs used to analyze the MLR alternative candidates were consolidated or modified as the V-22 progressed through development and operational testing, as shown in table 4.

Table 4: Evolution of Significant MV-22 Performance Parameters

Performance parameter	1993 requirements (at time of 1994 COEA)	1995 requirements	Current requirements	Requirement change
Cruise airspeed	**250 KTAS (threshold (T))**	**240 KTAS (T)**	**240 knots (T)**	Speeds slightly lowered
	270 KTAS (objective (O))	**270 KTAS (O)**	**270 knots (O)**	
Mission radius (five specified mission profiles)				
1. Amphibious troop lift	**50 NM (T)/110 NM (O) 24 troops; 2 round trips**	**50 NM x 2 (T) 110 NM x 2 (O)**	50 NM x 2 (T) 110 NM x 2 (O)	Consolidated
2. Amphibious external lift	**50 NM (T)/110 NM (O) 10,000 lbs; 1 round trip**	**50 NM x 1 (T) 110 NM x 1 (O)**	50 NM x 1 (T) 110 NM x 1 (O)	Consolidated
3. Land troop lift	**200 NM (T/O) 24 troops; 1 round trip**	**200 NM x 1 (T)/(O)**	200 NM x 1 (T)/(O)	Consolidated
4. Land external lift	**50 NM (T)/110 NM (O) 10,000 lb; 1 round trip**	**50 NM x 1 (T) 110 NM x 1 (O)**	**50 NM (T) 110 NM (O)**	
5. Amphibious pre-assault	200 NM (T/O)		**200 NM (T)**	
Internal payload	**24 troops (T/O)**	**24 troops (T)/(O)**	**24 troops (T)**	
External payload	**10,000 lbs. (T)**	**10,000 lbs. (T)**	**10,000 lbs. 50 NM (T)**	50 NM distance added
	15,000 lbs. (O)	**15,000 lbs. (O)**	**15,000 lbs. 50 NM (O)**	
Self-deployment	**2100 NM w/ one refuel (T)**	**2100 NM w/ one refuel (T)**	**2100 NM w/ one refuel (T)**	
	2100 NM w/o refuel (O)	**2100 NM w/o refuel (O)**	**2100 NM w/o refuel (O)**	
Air refueling capability	**Required**	**Required**		Consolidated
Vertical/short takeoff and landing capability	**Required**	**Required**		Consolidated
Shipboard compatibility	**Required**	**Required**		Consolidated
Survivability	**Resistance to 12.7 NM (T)**	**12.7MM @ 90% Velocity (T)**	**12.7MM @ 90% Velocity (T)**	
	Resistance to 14.5 NM (O)	**14.5MM @ 90% Velocity (O)**	**14.5MM @ 90% Velocity (O)**	

Performance parameter	1993 requirements (at time of 1994 COEA)	1995 requirements	Current requirements	Requirement change
Net ready			**100 percent of interfaces; services; policy-enforcement controls; and data correctness, availability and processing requirements designated as enterprise level or critical in the joint integrated architecture. Block C (T)** **100 percent of interfaces; services; policy-enforcement controls; and data correctness, availability and processing requirements in the joint integrated architecture. (O)**	Added KPP
Force protection			Permanently installed crashworthy internal fuel tanks that must be self-sealing (lower one-third), and nitrogen inerted. (T) Self-sealing entire tank. (O)	Added KPP
Reliability	Major components: flight hours between removals: 1500 hours	Mean time between failures: 1.4 hours (T) / 2.0 hours (O)	Mean flight hours between aborts (MFHBA): 17 hours (T)	Metric change
	Mission reliability: 85%	Mission reliability: 85%		No longer a metric
Maintainability	Maintenance man hours per flight hour (MMH/FH) : 11 hr (Goal)	Direct maintenance man hours per flight hour: 11 hours (O)	Direct maintenance man hours per flight hour: ≤ 20 hours (T) / ≤ 11 hours (O)	Added threshold level
Availability: mission capable (MC) rate	85% (T) 90% (O)	82% (T) 87% (O)	82% at maturity (60,000 hours) (T) / 87% (O)	Added 60,000-hour limit only after which threshold values are to be attained

Note: Boldface entries are key performance parameters

Source: GAO analysis of V-22 requirements documents.

While operational tests reports state that the MV-22 is meeting all its KPPs, according to program officials, modifications were made to balance

aircraft operational requirements against technical risks and program costs. For example, the amphibious external lift KPP was modified. In its 2000 operational test report, the office of the Director, Operational Test and Evaluation (DOT&E) found the MV-22 operationally effective but noted that weight increase of the aircraft could affect its performance against two KPPs: amphibious external lift and land assault external lift. Projections by DOT&E indicated that a 1,000-pound increase in aircraft weight would reduce performance in these metrics below threshold values. These two external lift KPPs of concern to DOT&E were combined into the land assault external lift KPP that had previously existed. This is one example of the 2001 modifications that consolidated 14 KPPs into 7 for the MV-22 variant.

In addition, during the 2000 operational test, DOT&E found the aircraft not operationally suitable in part due to reliability concerns. Mission capability (MC), one of the metrics used to measure suitability, was also modified in 2004 such that the MC rate does not have to be met until the aircraft reaches system maturity (60,000 flight hours). According to Marine Corps Headquarters officials, the aircraft currently has over 50,000 hours and may reach the 60,000 hour threshold within a year.

Concerns about V-22 weight increase and how it may affect aircraft performance have continued. In 2005, a DOT&E report on the second operational test of the MV-22 predicted a drop in performance for Block B aircraft due to weight increase. However, according to Navy operational testers who tested the MV-22 Block B in 2007, performance did not drop. DOT&E did not report on the 2007 Block B test. The program office is currently tracking weight increase in the MV-22 Block C as a moderate risk to the achievement of select KPPs.

Conclusions

After more than 20 years in development and 14 years since the last cost and operational effectiveness analysis was developed to reaffirm the decision to proceed with the V-22 program in 1994, the MV-22 experience in Iraq demonstrated that it can complete missions assigned in low-threat environments. Its speed and range were enhancements. However, operational tests and training exercises suggest that challenges may limit its ability to accomplish the full repertoire of missions of the legacy helicopters it is replacing. If so, those tasks will need to be fulfilled by some other alternative. Viewed more broadly, the MV-22 has yet to fully demonstrate that it can achieve the original required level of versatility. To be useful to the warfighter in a variety of climates and places, its ability to address and resolve a range of operational challenges must be evaluated.

Furthermore, suitability challenges that lower aircraft availability and affect the operations and support funding that may be required to maintain the fleet needs to be addressed. Based on the Iraq experience, the cost per flight hour is more than double the target estimate. In addition, savings in unit procurement cost expected as a result of the multiyear procurement contract may be offset by modifications and upgrades required on already-produced aircraft. DOD is therefore faced with the prospect of directing more money to a program, the military utility of which in some areas remains unproven.

The V-22 program has already received or requested over $29 billion in development and procurement funds. The estimated funding required to complete development and to procure additional V-22s is almost $25 billion (then-year dollars). In addition, the program continues to face a future of high operations and support cost funding needs, currently estimated at $75.4 billion for the life cycle of the program. This estimate may not accurately reflect the high cost per flight hour experienced by the MV-22 fleet so far. In light of the significant funding needs of a program that has not yet achieved all expected capabilities, now is a good time to consider the return on this investment as well as other less costly alternatives that can fill the current requirement.

To resolve this dilemma, the uses, cost, and performance of the V-22 need to be clarified and alternatives should be considered once again. To what degree is the V-22 a suitable and exclusive candidate for the operational needs of the Marine Corps and other services? How much will it cost? How much can DOD afford to spend? To what degree can a strategy be crafted for ensuring control over these future costs? If the V-22 is not or is only partially suitable, to what degree can another existing aircraft or some mixture of existing aircraft (even including V-22s) or a new aircraft perform all or some of its roles more cost effectively? Some consideration should be given to evaluating the roles such aircraft play in today's theaters of war and whether their performance warrant their cost.

Recommendations for Executive Action

We recommend the Secretary of Defense take the following two actions.

Given the difference between the now demonstrated and previously expected operational capabilities and costs of the V-22, we recommend that the Secretary of Defense re-examine the V-22 by requiring a new alternatives analysis to redefine and revalidate the proper mix of aircraft to achieve the Marine Corps' current and future medium-lift needs, possibly to include other services' operational uses. Such an analysis

should weigh V-22 capabilities and costs against the capabilities and costs of other existing helicopters and aircraft, upgrades to existing helicopters and aircraft, and potential future acquisitions, such as the upgrade to the CH-53 currently under development. This analysis should be conducted within the context of anticipated future budgetary constraints, and the services should then adjust total V-22 procurement and annual production and acquisition plans accordingly.

Given the unresolved operational effectiveness and suitability issues and increasing costs associated with the V-22 system, we also recommend that the Secretary of Defense require the Marine Corps to develop a prioritized strategy to improve system suitability (including identifying why measures such as component reliability and aircraft availability are low), reduce operational costs, and align future budget requests accordingly.

Agency Comments and Our Evaluation

DOD provided written comments on a draft of this report, which are reprinted in appendix II. DOD also separately provided technical comments, which we reviewed and incorporated as appropriate. In its written comments, DOD concurred with our recommendation for the development of a prioritized strategy to improve system suitability, reduce operational costs, and align future budget requests accordingly and non-concurred with our recommendation for a new V-22 alternatives analysis.

In its overall comments on our report, DOD wrote that "the report properly identifies reliability and availability concerns and also asserts that the operational effectiveness of the MV-22 may be deficient in some other environments." DOD noted that correcting the reliability and availability problems are a priority of the department and that actions are being taken to address these issues. DOD further commented that the MV-22 deployments in Iraq support "an assessment of operational effectiveness in the situation that existed." DOD also stated that our report leads to a similar conclusion. We note, however, that DOD does not address the concerns expressed in our report about operational challenges in "other environments."

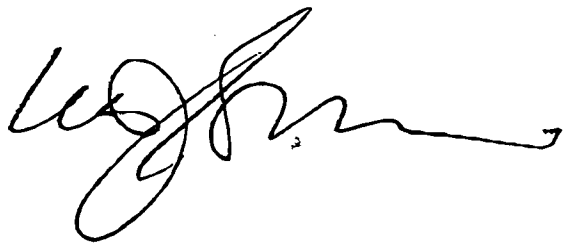
DOD concurred with our recommendation to develop a prioritized strategy to improve system suitability, reduce operational costs, and align future budget requests commenting that neither it nor the Marine Corps are satisfied with current reliability of the aircraft. They stated that their ability to adjust for components that have not achieved reliability rates projected by analytical models has been very limited. They further commented that the Program Manager's prioritization strategy will be

reviewed by the Under Secretary for Acquisition, Technology and Logistics.

In non-concurring with our recommendation for a new V-22 alternatives analysis, DOD stated that it supports validating required MV-22 quantities and the proper mix of aircraft, but not by means of a new V-22 alternatives analysis. DOD states that planning for all elements of Marine Corps aviation (including required quantities, location, and employment of medium-lift assets) and total force affordability are reviewed and updated annually in the Marine Aviation Plan. It notes that previous aviation plans have adjusted required quantities of aircraft and that more recently the fiscal year 2009 plan addressed the needs created by sustained irregular combat and adjusted CH-53K, AH-1Z, and UH-1Y quantities. It also comments that the Marine Aviation Plan is formulated in a constrained budget environment which ensures that both warfighting needs and affordability are weighed in deriving the optimum aviation force structure and that the Navy budget is scrutinized yearly during fall program reviews. While these studies provide useful information to decision-makers on aviation readiness, transition timetables, and the cost to acquire, maintain and support assets, they do not offer a comparison of a fuller range of medium-lift alternatives, including their costs, operational suitability, and operational effectiveness under varying scenarios and threat levels. Also, they do not include a sensitivity analysis to changes in key assumptions as would an alternatives analysis. We still believe the recommendation for a new V-22 alternatives analysis is warranted given the difference between the now demonstrated and previously expected operational capabilities and costs of the V-22. Furthermore, the development of a V-22 alternatives analysis could assure congressional decision-makers that a reasoned business case exists that supports the acquisition of an additional 282 V-22s and an expenditure of almost $25 billion in procurement funds in fiscal years 2010 and beyond.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. We will then send copies of this report to the Secretary of Defense; the Under Secretary of Defense for Acquisition, Technology and Logistics; the Chairman of the Joint Chiefs of Staff; and the Secretaries of the Air Force and Navy. This report will also be available at no charge on GAO's Web site at http://www.gao.gov.

If you have any questions about this report or need additional information, please contact me at (202) 512-4841 or sullivanm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Major contributors to this report were Bruce H. Thomas, Assistant Director; Jerry W. Clark; Kathryn E. Bolduc; Bonita J.P. Oden; Jonathan R. Stehle; Johanna Ayers; Jason Pogacnik; Robert S. Swierczek; Hi Tran; William Solis; and Marie P. Ahearn.



Michael J. Sullivan
Director
Acquisition and Sourcing Management

Appendix I: Scope and Methodology

To determine how the V-22 performed while deployed to Iraq, we gathered documents that identified the Osprey's performance requirements. By examining the program's Joint Operational Requirements Document and subsequent revisions, Capabilities Development Documents, and operational test reports (with a particular emphasis on sections pertaining to performance criteria), this allowed us to document required V-22 performance capabilities and its intended operational use. We interviewed officials at the Marine Corps Combat Development Command, the V-22 Program Office, and Commander, Operational Test and Evaluation Force to discuss the V-22 key performance parameters and other performance measures. We gathered actual deployment data (including aircraft missions flown, utilization rates, maintenance actions, and logistics support needs) from interviews with deployed squadrons and databases maintained at the squadron level, as well as from presentations and briefings. In addition to the GAO headquarters team meeting with officials from the first deployed squadron upon their return to the United States, we leveraged support from our audit team based in Iraq. The team interviewed deployed squadron officials, operators, maintainers, and contractor support personnel, observed the aircraft in operation, and had an opportunity to fly on the Osprey. We also received information compiled by the deployed squadron, briefings, lessons learned reports, after action reports, and consulted with other organizations (officials at the Director, Operational Test and Evaluation and Center for Naval Analysis) currently monitoring the aircraft. We compared expected to actual performance and during our interviews discussed changes in performance metrics.

To identify challenges the V-22 is experiencing, we examined the October 2000 Operational Evaluation/Operational Assessment report, the August 2005 Operational Evaluation report on the Block A configuration, and the June 2007 Follow-on Operational Test and Evaluation report for the MV-22 Block B. This allowed us to document deficiencies in the aircraft's performance. To support the current status of the aircraft's limitations, capabilities, and shortcomings, we obtained copies of the Yellow Sheet deficiency reports, Defense Acquisition Executive Summaries, the V-22 program office risk assessments, Naval Air Training and Operating Procedures Standardization (NATOPS) flight manuals (which identify operating limits for the aircraft), Director, Operational Test and Evaluation assessments of the Osprey, and Defense Contract Management Agency production reports along with aircraft acceptance forms, listing deviations and waiver. We also reviewed the Air Force's CV-22 Initial Operational Test & Evaluation report. We interviewed officials from the V-22 test community (Commander, Operational Test and Evaluation Force),

program office, officials at Marine Corps Headquarters assigned to the V-22 program, members of the crew and contractor support personnel onboard the U.S.S. Bataan and maintainers and operators that participated in the Realistic Urban Training exercise and discussed the aircraft's capabilities and shortfalls.

To assess whether the V-22 can accomplish planned operations, we reviewed the program's Joint Operational Requirements Document and subsequent revisions, Capabilities Development and Production Documents, the 1994 Cost and Operational Effectiveness Analysis for the Medium Lift Replacement Aircraft (which concluded the V-22 was the most cost-effective alternative) and the December 2003 Concept of Employment. We compared assumptions regarding the aircraft's characteristics and capabilities found in these studies to the V-22's current status and discussed the aircraft's performance with officials at the Marine Corps Headquarters, Center for Naval Analysis and in the Director, Operational Test and Evaluation office. We also examined reports published by other organizations monitoring the V-22.

In assessing program cost and lowered performance requirements, we evaluated actual cost data in the Selected Acquisition Reports from 1986 through 2007 and funding requests in the budget justification support for the V-22 program. This allowed us to document the increase in cost and expected funding needs over time and its impact on procurement unit cost. Data is presented in fiscal year 2009 dollars except for figure 8, which is in then-year dollars. In a note to figure 8, we provide those amounts in constant fiscal year 2009 dollars. To arrive at these amounts, we used base year 2005 dollar amounts from the December 2007 Selected Acquisition Report for the V-22 and escalated those amounts to constant fiscal year 2009 dollars using an inflation factor derived from the National Defense Budget Estimates For 2009. We examined data regarding the cost to correct deficiencies and fund planned upgrades, the multi-year procurement contract modification, modifications to the engine sustainment contract, service life expectancy for select aircraft components, Defense Contract Management Agency reports, and the cost for unreliable parts. During our interviews with deployed squadrons, we obtained cost data associated with maintaining and operating the aircraft in Iraq. We held discussions with the V-22 program office, officials at the Marine Corps Headquarters, contractor staff representing the prime contractor and the engine manufacturing company to better understand, factors impacting operations and support costs, and efforts in place to mitigate the risk of continued rising costs. We also examined the Navy and industry's plan to address reliability and maintainability concerns as

documented in executive supportability summit briefings. In assessing whether or not the aircraft has met key performance parameters, we examined the 1994 Cost and Operational Effectiveness Analysis for the Medium Lift Replacement Aircraft to gain an understanding of the assumptions used in the study and their impact on the V-22's effectiveness over the helicopter candidates along with each candidate's life cycle cost estimates. Using recent requirements documents, we identified changes in the V-22 performance parameters since the 1994 COEA was published.

In performing our work, we focused our work efforts primarily on the MV-22 and obtained information and interviewed officials from the V-22 Program Office, Patuxent River, Maryland; Headquarters United States Marine Corps (Pentagon) Arlington, Virginia; Marine Medium Tiltrotor Squadron (VMM 263 and 266), New River, North Carolina; Director, Operational Test and Evaluation, Arlington, Virginia; Center for Naval Analysis, Alexandria, Virginia; Defense Contract Management Agency, Amarillo, Texas; Commander, Operational Test and Evaluation Force, Norfolk, Virginia; Marine Corps Combat Development Command (MCCDC), Quantico, Virgina; Rolls Royce, NAVAIR and the Center for Naval Analysis representatives on board the U.S.S. Bataan. Our audit team in Iraq met with the Commanding General, Multi-National Force-West; Commanding Officer - Third Marine Air Wing Forward Aviation Logistics Department; Commanding Officer and personnel from the Regimental Combat Team; Commanding Officer and personnel from HMM 161, CH-46 squadron; VMM-266 (maintainers, operators, and crew chiefs); V-22 contractor representatives; all located at Al Asad Air Base, Anbar Province.

We conducted this performance audit from June 2008 to May 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION
TECHNOLOGY
AND LOGISTICS

APR 24 2009

Mr. Michael J. Sullivan
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the GAO draft report, GAO-09-482, "DEFENSE ACQUISITIONS: Assessments Needed to Address V-22 Aircraft Operational and Cost Concerns to Define Future Investments," dated April 7, 2009 (GAO Code 120746). Detailed comments on the report recommendations are enclosed.

The DoD non-concurs with recommendation one and concurs with recommendation two. The report properly identifies reliability and availability concerns and also asserts that the operational effectiveness of the MV-22 may be deficient in "some other environments." Correcting the reliability and availability problems is a priority for the Department and actions are being taken to address these issues. But reliability and availability are factors that contribute to operational suitability, not operational effectiveness. Three successive MV-22 deployments in harsh environments provide evidence that supports an assessment of operational effectiveness in the situation that existed. The aircraft was pressed into combat operations in Iraq at the first opportunity. It conducted every assault support mission in theater in low to medium threat environments. The MV-22 is arguably the most survivable, versatile, and capable medium-lift airframe in the Iraq Theater. The speed, range, and endurance of the MV-22B broadened Major General Kelly's (Commanding General, Multi-National Forces - West) area of influence as articulated, "I could dominate Al Anbar Province, because I had V-22s. . . I couldn't do what I did with just helicopters." The evidence in the report leads to a conclusion that the MV-22 was operationally effective in Iraq.

We appreciate the opportunity to comment on the draft report. Technical comments were provided separately for your consideration. My point of contact for this effort is Mr. Michael Walsh, 703-695-1700, Michael.Walsh@osd.mil.

Sincerely,

David G. Ahern
Director
Portfolio Systems Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED APRIL 7, 2009
GAO-09-482 (GAO CODE 120746)

"DEFENSE ACQUISITIONS: ASSESSMENTS NEEDED TO ADDRESS V-22 AIRCRAFT OPERATIONAL AND COST CONCERNS TO DEFINE FUTURE INVESTMENTS"

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS

GAO RECOMMENDATION 1: The GAO recommends that the Secretary of Defense re-examine the V-22 by requiring a new alternatives analysis to redefine and revalidate the proper mix of aircraft to achieve the Marine Corps' current and future medium lift needs, possibly to include other Services' operational uses. (p.35/GAO Draft Report)

DOD RESPONSE: Non-concur. DoD supports validating required MV-22 quantities and the proper mixture of aircraft, but not by means of a new V-22 alternatives analysis. Planning for all elements of Marine Corps aviation (including required quantities, location and employment of medium lift assets) and total force affordability are reviewed and updated annually in the Marine Aviation Plan. Previous Aviation Plan updates have adjusted required quantities for KC-130Js and AV-8Bs. More recently, the FY 2009 Aviation Plan addressed the needs created by sustained irregular combat and adjusted CH-53K, AH-1Z and UH-1Y quantities. The Marine Aviation Plan is formulated in a constrained budget environment which ensures that both war fighting needs and affordability are weighed in the derivation of the optimum aviation force structure. Additionally, the Department of the Navy budget is scrutinized yearly by the Office of the Secretary of Defense during Fall programs reviews.

Performance attributes such as parts reliability, aircraft availability and operating costs are monitored and factored into Aviation Plan updates. As more is learned about the MV-22B's achieved performance and how best to employ its inherently transformational capabilities within the Marine Air Ground Task Force, future adjustments to planned quantities of MV-22 may be appropriate.

GAO RECOMMENDATION 2: The GAO recommends that the Secretary of Defense require the Marine Corps to develop a prioritized strategy to improve system suitability, reduce operational costs, and align future budget requests accordingly. (p.35/GAO Draft Report)

DOD RESPONSE: Concur. Neither DoD nor the Marine Corps is satisfied with the current reliability, which translates into availability, nor operating cost of the aircraft. With over 50% of the total program flight hours accumulating in the last two years, the ability to adjust for components that have not achieved Mean Time Between Failure rates projected by analytical models has been very limited. The Under Secretary for Acquisition, Technology, and Logistics will review the Program Manager's comprehensive strategy to address aircraft readiness and the Marine Corps funding allocation.

Related GAO Products

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-09-326SP. Washington, D.C.: March 30, 2009.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-08-467SP. Washington, D.C.: March 31, 2008.

Defense Acquisitions: DOD's Practices and Processes for Multiyear Procurement Should Be Improved. GAO-08-298. Washington, D.C.: February 7, 2008.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-07-406SP. Washington, D.C.: March 30, 2007.

Defense Acquisitions: Assessments of Selected Major Weapon Programs. GAO-06-391. Washington, D.C.: March 31, 2006.

Defense Acquisitions: Assessments of Selected Major Weapon Programs. GAO-05-301. Washington, D.C.: March 31, 2005.

Defense Acquisitions: Assessments of Major Weapon Programs. GAO-04-248. Washington, D.C.: March 31, 2004.

Defense Acquisitions: Assessments of Major Weapon Programs. GAO-03-476. Washington, D.C.: May 15, 2003.

Defense Acquisitions: Readiness of the Marine Corps' V-22 Aircraft for Full-Rate Production. GAO-01-369R. Washington, D.C.: February 20, 2001.

Navy Aviation: V-22 Cost and Capability to Meet Requirements Are Yet to Be Determined. GAO/NSIAD-98-13. Washington, D.C.: October 22, 1997.

Navy Aviation: V-22 Development—Schedule Extended, Performance Reduced, and Costs Increased. GAO/NSIAD-94-44. Washington, D.C.: January 13, 1994.

Naval Aviation: Status of V-22 Osprey Full-Scale Development. GAO/T-NSIAD-91-19. Washington, D.C.: April 11, 1991.

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Defense Acquisition Programs: Status of Selected Systems. GAO/NSIAD-90-30. Washington, D.C.: December 14, 1989.

DOD Acquisition Programs: Status of Selected Systems. GAO/NSIAD-88-160. Washington, D.C.: June 30, 1988.

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